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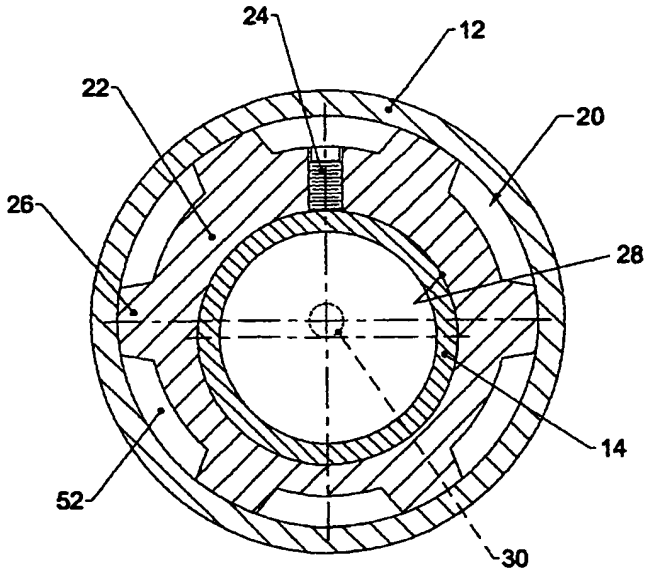
(54) Title: BORE CLEANING



(57) Abstract: The invention relates to a bore cleaning method and apparatus, fore cleaning a bore drilled to access a subsurface hydrocarbon-bearing formation. In one embodiment of the invention, bore cleaning apparatus for cleaning a bore (10) includes a tubing string (14) positioned relative to a casing (12) in the bore (10) by centralisers (20, 21). The centraliser (20) is fixed to the string (14) and rotates with the string, whilst the centraliser (21) is rotatable relative to the string (14) and stationary in the casing (12). The centralisers (20, 21) offset the string in the casing (12) to induce a sweeping eccentric movement of the string (14) when the string is rotated, sweep cleaning fluid around the bore (10). This is assisted by blades (26, 46) on the centralisers (20, 21).

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BORE CLEANING

This invention relates to a bore cleaning method, and in particular to a method of cleaning a bore drilled to access a subsurface hydrocarbon-bearing formation.

In the oil and gas exploration and production industry, bores are drilled from surface to access subsurface hydrocarbon-bearing formations. During the drilling operation, drilling fluid, known as "mud", is circulated in the bore to *inter alia* carry drill cuttings out of the bore to the surface. The drilled bores are then lined with metal tubing, known as casing or liner, the casing being cemented in the bore by injecting cement slurry between the casing and the bore wall. Once the bore has been completed, oil and gas are carried through the bore, from the hydrocarbon-bearing formation to the surface, via production tubing which is located within the casing. The annulus between the production tubing and the casing may be filled with a fluid such as brine and will accommodate seals, known as packers, and possibly other tools and devices, between the tubing and the casing. The circulation of drilling mud during the drilling operation, and the circulation of cement slurry during casing cementing operations, results in solid material gathering in the bore, and it is desirable that this solid material is removed from the bore before production commences; the

material may settle on top of packers and other tools and devices in the annulus between the production tubing and the casing, creating difficulties in subsequent workover or repair operations.

At present, the bore, and in particular the bore annulus, may be cleaned by circulating "clean" fluid through the bore, however this is time consuming and often of limited effectiveness; particularly in deviated bores, solid material tends to collect on the low side of the bore, and may not be dislodged or entrained by the circulated cleaning fluid.

It is among the objectives of embodiments of the present invention to obviate or mitigate these disadvantages, and to provide an improved well cleaning method.

According to a first aspect the present invention, there is provided a bore cleaning method, the method comprising the steps of:

passing fluid through a bore annulus externally of a first tube, the first tube defining a non-circular outer profile; and

rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

Conveniently, the method further comprises the step of coupling adjacent sections of tube together such that the outer profiles of the adjacent sections are not axially

continuous along the length of the tube. The method may further comprise the step of coupling adjacent sections of tube together such that the outer profiles of the adjacent sections centralise the tube in the bore.

According to second aspect of the present invention there is provided a bore cleaning method, the method comprising the steps:

passing fluid through a bore annulus externally of a first tube;

offsetting at least a portion of the tube relative to the bore axis; and

rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

The variation in the radial extent of the annulus creates turbulence and agitation in the fluid in the annulus, thus facilitating the entrainment of solids in the fluid, which solids may be drill cuttings, cement particles, or other debris. In particular, it is believed that the rotation of the offset tube produces a sweeping motion in the fluid, tending to dislodge and facilitate entrainment of solids lying in the annulus.

Preferably, in the second aspect, the tube is substantially cylindrical and the tube axis is offset from the bore axis. The offset may be provided by mounting at least one offsetting member, such as a centraliser or sleeve, on the tube. The centraliser may rotate with the

tube, that is be fixed to the tube and rotate relative to the bore. Alternatively, the centraliser may be rotatable relative to the tube, such that the centraliser will tend not to rotate in the bore. This may be achieved by providing a bearing, possibly an offset bearing, between the tube and the centraliser. As in the first aspect, the tube may define a non-circular outer profile, for example the tube may be oval or square, or the tube wall may carry a longitudinally extending rib, extension, or the like. Conveniently, the outer profiles of adjacent sections of such a tube are not continuous along the length of the tube, but rather are arranged to centralise the tube in the bore. For example, the orientation of adjacent sections of oval pipe vary by 90° such that the tube axis remains substantially central as the tube rotates.

The fluid will typically be passed down from surface through the tube, and then return to the surface via the annulus. The fluid may be a cleaning fluid, typically a brine, or may be drilling fluid.

The tube may form part of a tubing string, and the tubing string may be offset along some or all of its length.

The tube may be completion or production tubing. Alternatively, the tube may be drill pipe or the like.

The bore may be an open hole, or may be lined with a larger diameter second tube such as casing or liner. The

first tube may have been run into the bore with the second tube, or may be run into the bore subsequent to the second tube.

According to a further aspect of the present invention there is provided bore cleaning apparatus comprising:

a first tube for location in a bore;

means for offsetting at least a portion of the tube relative to the bore axis;

means for circulating fluid between the tube and the bore wall; and

means for rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

The circulating means may comprise a surface, subsurface or downhole pump. Alternatively, the circulating means may take the form of blades or other impeller forms provided on the tube.

The rotating means may comprise a surface motor, such as a top drive or a rotary table, or may comprise a downhole motor.

According to a still further aspect of the present invention there is provided bore cleaning apparatus comprising:

a first tube for location in a bore, the tube defining a non-circular outer profile;

means for circulating fluid between the tube and the bore wall; and

means for rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

The tube may be oval, teardrop shaped, elliptical or square, or indeed of any suitable non-circular form. Alternatively, the tube wall may be circular and carry a longitudinally extending blade, rib, extension, or the like. Preferably, the outer profiles of adjacent sections of tube are not axially continuous along the length of the tube, but rather are arranged to centralise the tube in the bore, and thus obviate the requirement to provide stabilisers or centralisers in combination with the tube. For example, the orientation of adjacent sections of oval pipe may alternate by 90° such that the tube axis remains substantially central in the bore as the tube rotates. Alternatively, the orientation of the ovality may vary along the length of the tube in a gentle helix.

The manufacture of such tube may be relatively straightforward, for example a conventional length of drill pipe may simply be passed between rollers and cold formed to create an oval profile.

According to a yet further aspect of the present invention, there is provided a bore cleaning method, the method comprising the steps of:

passing fluid through a bore annulus externally of a first tube; and

rotating the tube such that the radial extent of the

annulus varies with rotation of the tube.

According to a still further aspect of the present invention, there is provided bore cleaning apparatus comprising:

a first tube for location in a bore;

means for circulating fluid between the tube and the bore wall; and

means for rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of apparatus for use in a bore cleaning method in accordance with a preferred embodiment of the present invention;

Figure 2 is an enlarged sectional view on line 2-2 of Figure 1;

Figure 3 is an enlarged sectional view on line 3-3 of Figure 1;

Figure 4 is a schematic view of bore cleaning apparatus in accordance with another aspect of the present invention; and

Figure 5 is an enlarged cross-sectional view on line 5-5 of Figure 4.

Reference is first made to Figure 1 of the drawings, which illustrates a bore 10 being cleaned using a method in

accordance with a preferred embodiment of the present invention. The illustrated bore 10 has been lined with steel casing 12 and accommodates a smaller diameter production or completion tubing string 14. The Figure illustrates two of the "pipe joints" 16, 17 forming the production string 14 and which are coupled in conventional fashion by pin and box couplings 18.

The string 14 is positioned relative to the casing 12 by a number of centralisers 20, 21, two of which are illustrated in Figure 1. The first of these centralisers 20 is illustrated in Figure 2 of the drawings, which shows a cross section of a "rotating" centraliser 20, that is a centraliser which is fixed to the string 14 and rotates with the string 14. The centraliser 20 comprises a generally annular body 22 which is axially and rotationally fixed to the string 14 by a lock screw 24. The body 22 defines six blades 26 defining a swept diameter slightly smaller than the internal diameter of the casing 12.

It will be noted from Figure 2 that the radial extent of the body 22 varies, from a maximum thickness at the lock screw location, to a minimum thickness on the opposite side of the body. This has the effect of offsetting the body bore 28, and thus offsetting the string 14, relative to the blade faces and thus also relative to the casing 12. Accordingly, as the string 14 is rotated in the bore 10, the string 14 rotates eccentrically, the path of the string

axis 14 being illustrated by the chain-dotted circle 30.

Reference is now made to Figure 3 of the drawings, which shows a cross section of a "non-rotating" centraliser 21, that is a centraliser which is rotatable relative to the string 14 and tends not to rotate within the casing 12. The centraliser 21 comprises a generally annular body 42 which is mounted on the string 14 via an eccentric bearing 43 fixed relative to the string 14 by a lock screw 44. As with the centraliser 20, the body 42 defines six blades 46 defining a swept diameter slightly smaller than the internal diameter of the casing 12.

As the string 14 is rotated in the bore 10, the centraliser body 42 remains stationary with the bearing 43 inducing an eccentric rotation of the string 14, the path of the string axis 14 being illustrated by the chain-dotted circle 50.

In use, the string 14 is positioned in the casing 12, either after the casing 12 has been run in and cemented in place, or in some cases the production string 14 and casing 12 are run in together. The cementing operations, and other operations carried out in the bore, will have resulted in solid particles gathering the bore 10, particularly on the low side of inclined portions of the bore 10. To dislodge and then remove these particles from the bore 10, cleaning fluid is circulated down through the string 14 and up through the annulus 52 between the string

14 and the casing 12, while the string 14 is rotated from surface.

The offset created by the centralisers 20, 21 induces a sweeping eccentric movement of the string 14, which tends to sweep the cleaning fluid around the bore 10. The fluid thus provides a more effective scouring action than solely axial flow, and the sweeping action is effective in agitating solid material which has settled on the low side of inclined bores. Also, the sweeping motion of the string 14 tends to induce helical fluid flow in the annulus 52, improving fluid distribution around the annulus 52.

The motion of the string 14 may be controlled by the relative orientation and positioning of the centralisers 20, 21, a "random" orientation producing a random eccentric movement or "squirming" motion, while aligning the offsets will produce a single sweeping motion of the entire string.

It will therefore be apparent to those of skill in the art that the above described embodiments of the invention provide for more effective and efficient cleaning of a bore than is achievable using conventional axial cleaning fluid flow. Thus, the cleaning operation is completed within a shorter timescale and using a smaller volume of cleaning fluid, all of which reduces cleaning costs.

Reference is now made to Figures 4 and 5 of the drawings, which illustrate bore cleaning apparatus in accordance with a further embodiment of the present

invention. The apparatus 50 is shown located in a casing-lined bore 52, and comprises a number of pipe joints 54, 55 joined by conventional connectors. Each pipe joint 54, 55 comprises three oval sections 54a, 54b, 54c and 55a, 55b, 55c, one of which is illustrated in enlarged cross-section in Figure 5. It will be noted from Figure 4 that the ovality of adjacent sections are oriented 90° from one another.

When the pipe joints 54, 55 are rotated in the course of a bore cleaning operation, the rotation of the oval sections tends to sweep the cleaning fluid around the annulus between the pipe joints and the bore wall, thus tending to dislodge any drill cuttings, cement residue or other material which has settled in the bore, and allowing the dislodged material to be circulated out of the bore.

It will be apparent to those of skill in the art that the above described embodiments are merely exemplary of the present invention and that modifications and variations may be made thereto without departing from the scope of the invention. For example, in other embodiments, the offset may be induced by providing an imbalance in the tube, which may be coaxial with the bore when stationary, such that on rotating the tube the imbalance causes the tube to bow or bend. Further, the above embodiments specifically describe a cleaning operation; embodiments of the invention may also be utilised in drilling operations, where the

eccentric or sweeping motion of the rotating drill string serves to facilitate entrainment of drill cuttings in circulating drilling fluid and prevent settlement of drill cuttings, and references herein to "bore cleaning" are intended to encompasses such uses of the invention.

CLAIMS

1. A bore cleaning method, the method comprising the steps of:

passing fluid through a bore annulus externally of a first tube, the first tube defining a non-circular outer profile; and

rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

2. A method as claimed in claim 1, wherein the method further comprises the step of coupling adjacent sections of tube together such that the outer profiles of the adjacent sections are not axially continuous along the length of the tube.

3. A method as claimed in either of claims 1 or 2 wherein the method further comprises the step of coupling adjacent sections of tube together such that the outer profiles of the adjacent sections centralise the tube in the bore.

4. A bore cleaning method, the method comprising the steps of:

passing fluid through a bore annulus externally of a first tube;

offsetting at least a portion of the tube relative to the bore axis; and

rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

5. The method of claim 4, wherein the tube is substantially cylindrical and the tube axis is offset from the bore axis.

6. The method of claim 5, wherein the offset is provided by mounting at least one offsetting member on the tube.

7. The method of claim 6, wherein the offsetting member is rotated with the tube.

8. The method of claim 6, wherein the offsetting member rotates relative to the tube.

9. The method of claim 8, wherein a bearing is provided between the tube and the offsetting member.

10. The method of claim 4, wherein the tube defines a non-circular outer profile.

11. The method of any of the preceding claims, wherein the fluid is a cleaning fluid.

12. The method of any of claims 1 to 10, wherein the fluid is a drilling fluid.

13. The method of any of the preceding claims, wherein the tube is completion or production tubing.

14. The method of any of claims 1 to 12, wherein the tube is drill pipe.

15. The method of any of the preceding claims, wherein the bore is an open hole.

16. The method of any of claims 1 to 14, wherein the bore is lined with larger diameter second tube.

17. The method of claim 16, wherein the first tube is run into the bore with the second tube.

18. The method of claim 16, wherein the first tube is run into the bore subsequent to the second tube.

19. Bore cleaning apparatus comprising:

a first tube for location in a bore, the tube defining a non-circular outer profile;

means for circulating fluid between the tube and the bore wall; and

means for rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

20. Bore cleaning apparatus as claimed in claim 19, wherein the tube is one of oval, teardrop shaped, elliptical and square.

21. Bore cleaning apparatus as claimed in claim 19, wherein the tube wall is circular and carries one of a longitudinally extending blade, rib, and extension.

22. Bore cleaning apparatus as claimed in any one of claims 19 to 21, wherein the outer profiles of adjacent sections of tube are not axially continuous along the length of the tube.

23. Bore cleaning apparatus as claimed in claim 22, wherein the outer profiles of adjacent sections of tube are arranged to centralise the tube in the bore.

24. Bore cleaning apparatus as claimed in claim 23 wherein the tubes are oval, the orientation of adjacent sections of pipe alternating by 90° such that the tube axis remains substantially central in the bore as the tube rotates.

25. Bore cleaning apparatus as claimed in claim 23, wherein the tubes are oval, the orientation of the ovality varying along the length of the tube in a gentle helix.

26. Bore cleaning apparatus as claimed in either of claims 24 or 25, wherein the tube is manufactured by passing a conventional length of drill pipe between rollers and cold forming to create an oval profile.

27. Bore cleaning apparatus comprising:

a first tube for location in a bore;

means for offsetting at least a portion of the tube relative to the bore axis;

means for circulating fluid between the tube and the bore wall; and

means for rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

28. Bore cleaning apparatus as claimed in any of claims 19 to 27, wherein the circulating means comprises one of a surface, subsurface and downhole pump.

29. Bore cleaning apparatus as claimed in any of claims 19 to 27, wherein the circulating means takes the form of impeller forms provided on the tube.

30. A bore cleaning method, the method comprising the steps of:

passing fluid through a bore annulus externally of a first tube; and

rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

31. Bore cleaning apparatus comprising:

a first tube for location in a bore;

means for circulating fluid between the tube and the bore wall; and

means for rotating the tube such that the radial extent of the annulus varies with rotation of the tube.

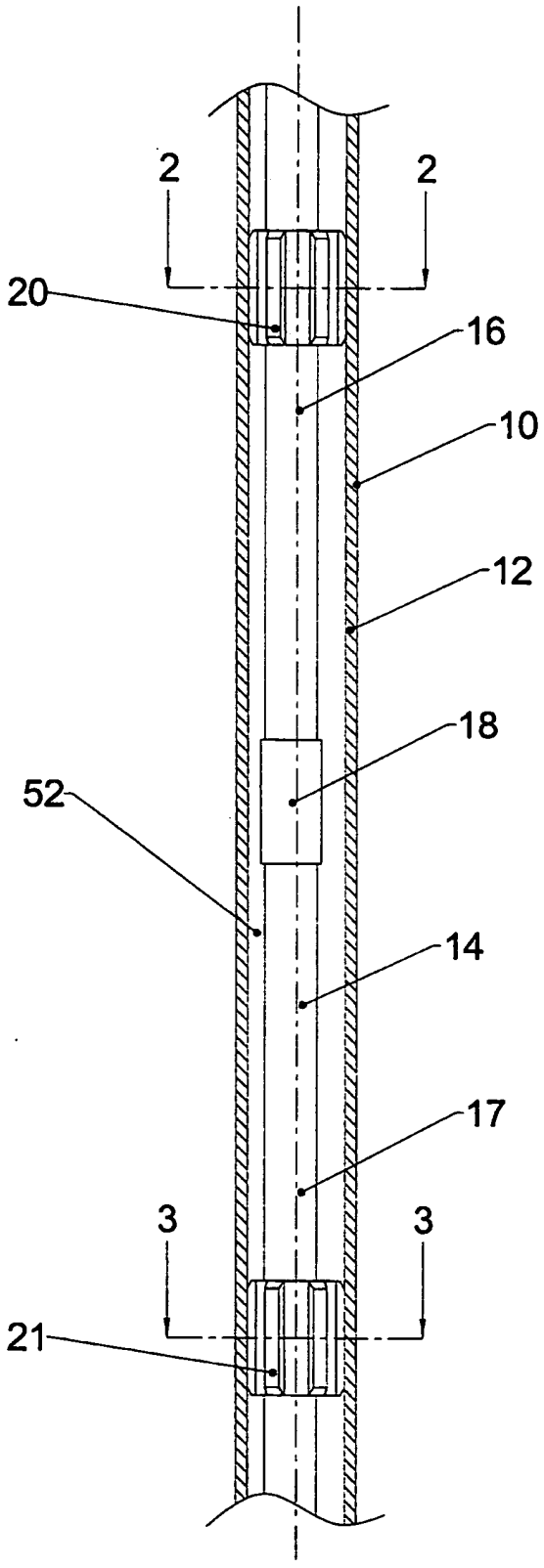

Figure 1

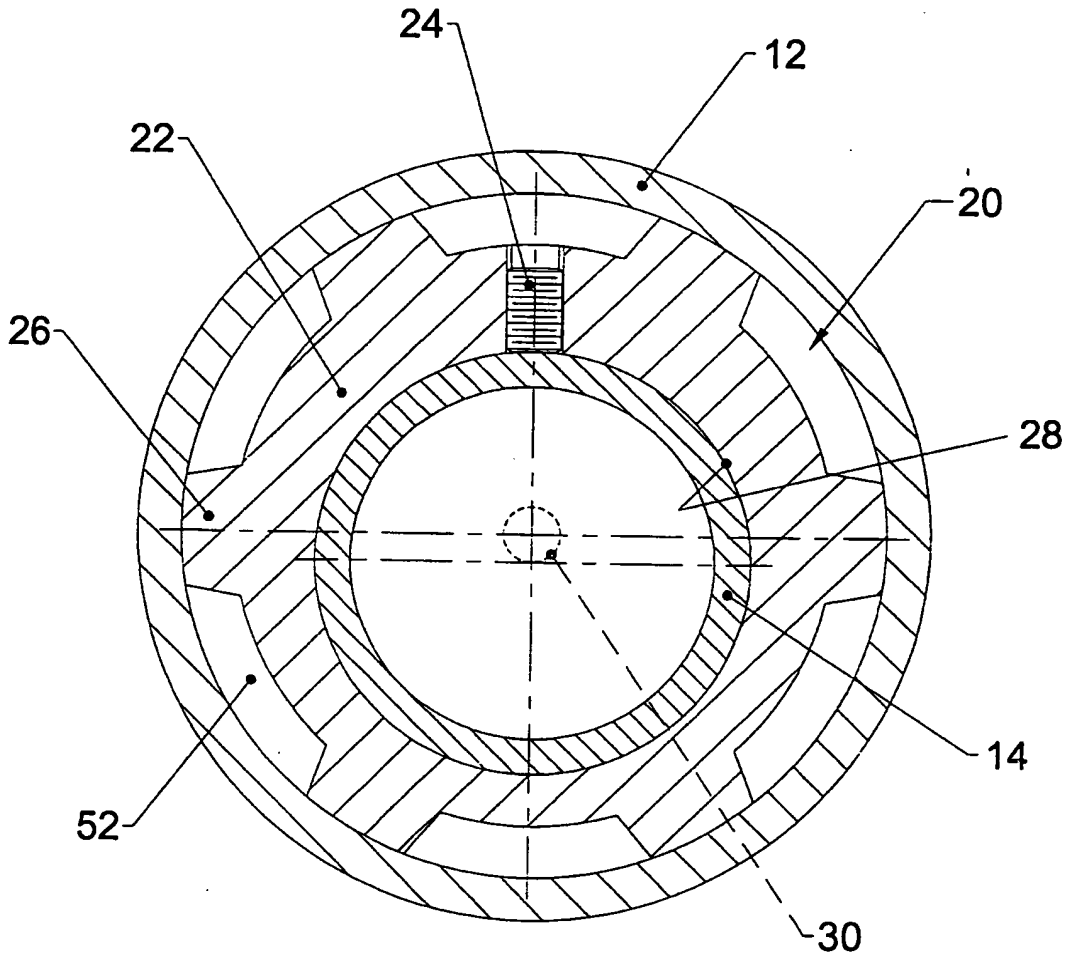

Figure 2

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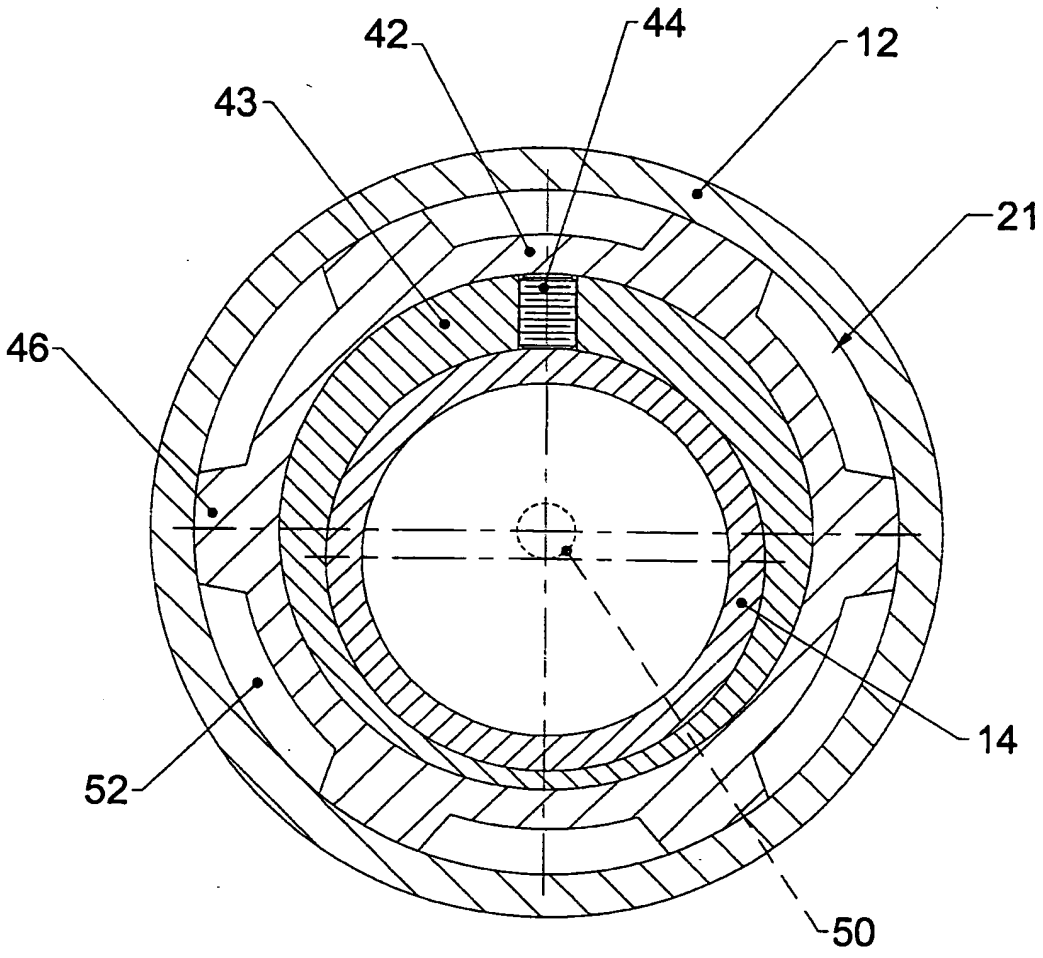

Figure 3

Section on 3 - 3

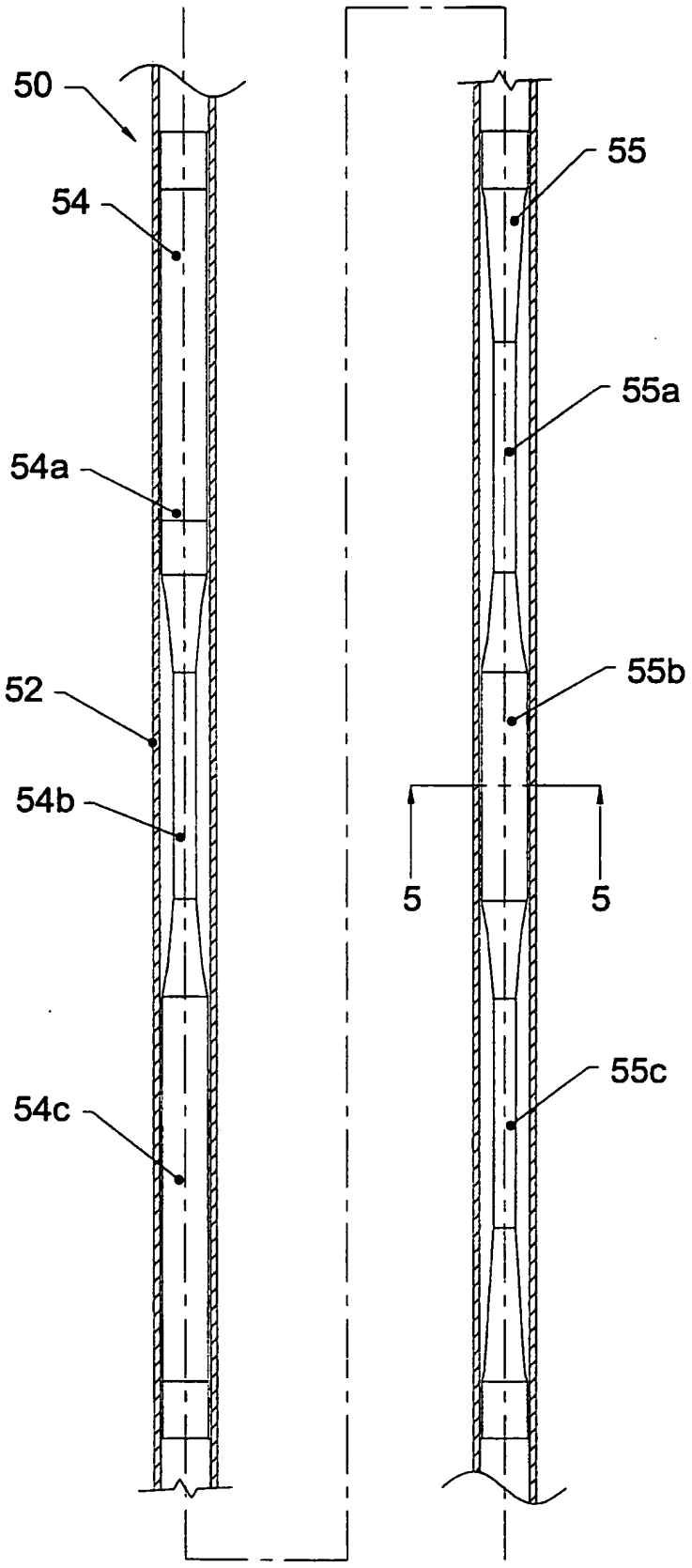

Figure 4

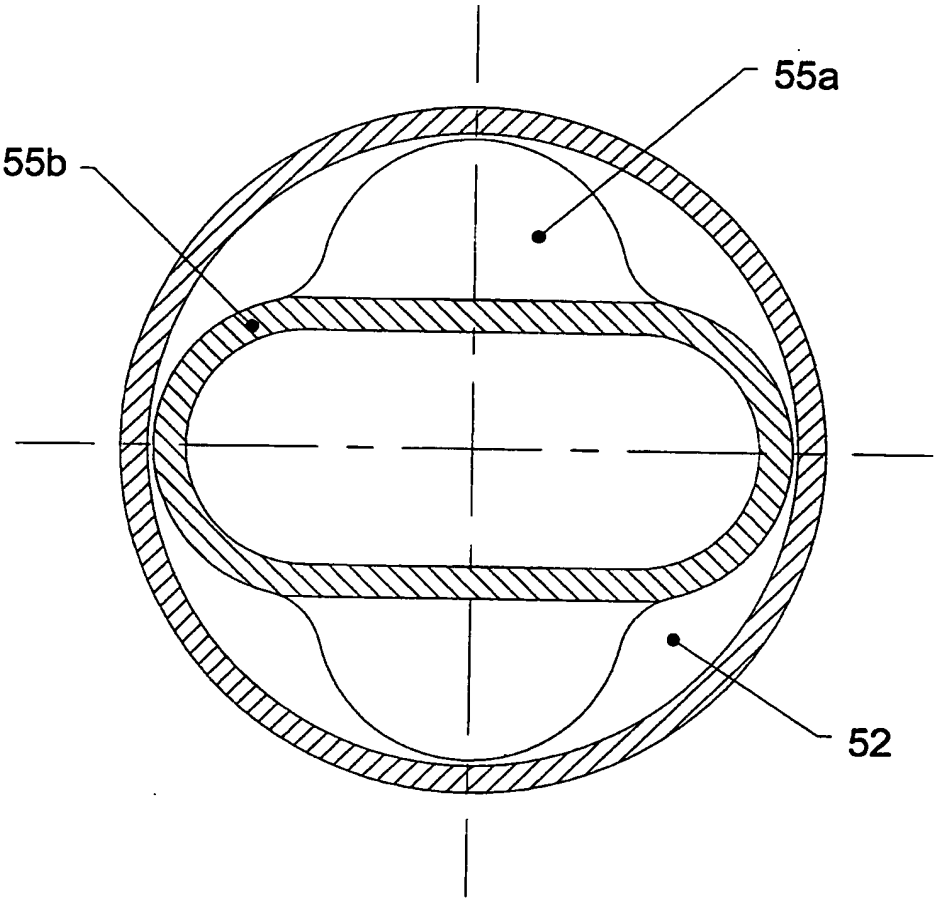

Figure 5

Section on 5 - 5